

Mem. Natn. Sci. Mus., Tokyo, (7), September 20, 1974

Fouling Bryozoans in the Black Lip Oyster Culture Fisheries at Ishigaki-jima, Yaeyama Islands

By

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馬渡 静夫* : 石垣島の養殖クロチ ヨウガイに着生する苔虫類

In my trip from 20th June to 4th July 1973 to the Ryukyu Islands I had a chance to collect sedentary organisms occurring in coral reefs along the coasts of Ishigaki-jima, Iriomote-jima and Miyako-jima. The present paper is a part of my study of bryozoan fauna of the Islands, dealing with the fouling species appeared in the black lip oyster culture at Ishigaki-jima. The Ryukyu Pearl Industry Company has kept a culture farm in the Kabira Bay these thirty years and an amount of black pearls are yearly produced out of the shells. An immense number of black lip oyster shells, *Pinctada margaritifera* (LINNAEUS), are suspended at several meters depth, and cultured from three to five years in the bay. Once or twice of troublesome shell cleaning operations are necessary in a year to scrape off the fouling organisms accumulated on the shell surface to keep healthy growth of the shell. Main fouling organisms consist of sponges, hydrozoans, sea anemones, tube-worms, sedentary bivalves, bryozoans, tunicates and calcareous algae. The total weight of foulers reaches up to 100 grammes per shell. The bryozoan fouling is important in its rapid spreading activities over the shell or in its dense bushy growth soon reaching over 5 centimeters in height. The following is the brief account of bryozoans found on the present occasion.

1. *Aetea truncata* (LANDSBOROUGH, 1852)

Anguinaria truncata LANDSBOROUGH, 1852, p. 288, pl. 16, fig. 57.

Aetea truncata: BUSK, 1852, p. 31; HARMER, 1926, p. 196, pl. 13, figs. 5-7; PRENANT & BOBIN, 1966, p. 86, figs. 20-21; MAWATARI, 1973, p. 415, fig. 2.

This delicate species was commonly found forming web-like incrustations spreading on almost all shells. The distal erect portion of zoecium has often been broken and leaves only a circular pore at the terminal end of stolonate proximal half.

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2. *Thalamoporella rozieri* (AUDOUIN, 1826)

(Fig. 1, A-J; Pl. 20: 5-10)

Flustra rozieri AUDOUIN, 1826, p. 239.

Thalamoporella rozieri: HARMER, 1926, p. 292, pl. 19, figs. 3-13; OKADA & MAWATARI, 1936, p. 131.

Description. The zoarium is unilamellar and incrusting, forming a circular or irregular disk of several centimeters in diameter. The zooecia are elliptical or elongate hexagonal, more or less widened about the middle of the length. They are arranged in radiating or parallel lines and divided by a raised, beaded rim except the smooth non-tuberculated adoral area. The zooecial aperture is terminal, subcircular, with arched thin peristome ending to lateral condyles. The proximal half is provided with a rounded broad sinus frilled by a median extension of beaded lateral rim. The operculum is semicircular, with a marginal sclerite but with only the proximal inner spurs instead of a complete basal sclerite at the level of condyles.

The depressed cryptocyst occupies more than half of the frontal and is granular and equally perforated with numerous small rounded pores. The symmetrically disposed large

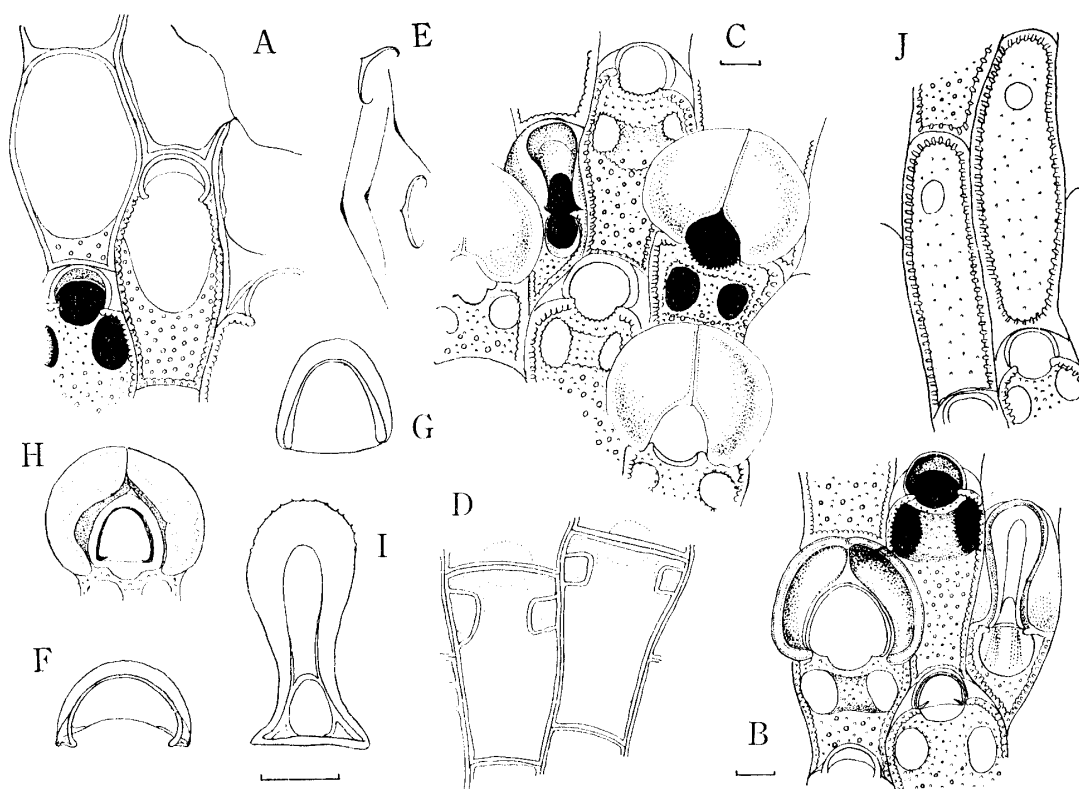


Fig. 1. *Thalamoporella rozieri* (AUDOUIN) (Scale 0.1 mm)

A. Incomplete zooecia at the zoarial margin. B. Zooecia, avicularium and developing oecium. C. Completed oecia consisted of two lobes. D. Basal insertions. E. Inner calcareous spicules. F. Operculum of ordinary zooecium. G. Operculum of matured zooecium. H. Nearly completed oecium closed by operculum. I. Spatulate mandible. J. Kenozoecia.

opesiules are circular or elliptical and usually not very different in size. Basal insertions of both opesiules form asymmetrical quadrate closings with the lateral wall. The median granular zooecial tube is deeply depressed and terminates distally to the raised aperture.

The vicarious avicularium occupies the disto-lateral position at the bifurcation of zooecial rows and is elongate elliptical, shorter than the sister zooecium which is symmetrical in structures. The triangular avicularian cryptocyst is granular, bordered by beaded rim and without opesiules. The rostrum is spatulate, distinctly expanded distally and narrowed proximally by the development of smooth raised lateral walls. A pair of lateral condyles are prominent and subdivide the avicularian aperture into the elliptical distal and semicircular proximal halves. The mandible is spatular with widened distal half fitted to the rostrum and reinforced with long parallel main sclerites and a slightly curved basal bar or lateral hinge projections articulating with the lateral condyles. The rounded distal margin is toothed minutely.

The matured ooecium-bearing zooecia are more or less wider than the ordinary zooecia, and provided with shorter granular cryptocyst carrying large circular opesiules. The aperture is large and semi-elliptical with rounded sinus. The distal half is occupied with a prominent globose ooecium, wider than long. The smooth imperforate ooecial cover was made of double-layered lateral halves meeting and fusing into a median suture. The ooecial orifice is of a shape of the gothic arch with pointed top extending about half of the ooecium. It is closed by a fitted ooecial operculum with thickened sclerites which articulates with the zooecial operculum. The internal spicules consists of long and short compasses and small calipers with hooked end.

Affinities. Especially in the presence of spatulate vicarious avicularia with toothed mandibles the present material agrees undoubtedly with *T. rozieri* (AUDOUIN). A minute adoral tubercle described by HARMER is completely absent in my specimens, and the vicarious avicularium is more or less different in the smaller proximal half and the narrower rostrum, but other characters agree with the description and figures of Siboga collections.

3. *Bugula neritina* (LINNAEUS, 1758)

Sertularia neritina LINNAEUS, 1758, p. 815.

Bugula neritina: OKEN, 1815, p. 89; HARMER, 1926, p. 432, 436; PRENANT & BOBIN, 1966, p. 492, fig. 162 MAWATARI, 1951, p. 47, figs. 1-8; 1952, p. 264;

This cosmopolitan bushy form was found attaching to the black lip oyster shells but less luxuriant than the following species.

4. *Bugula subglobosa* HARMER, 1926

Bugula subglobosa HARMER, 1926, p. 44, pl. 32, figs. 15-18; Silén, 1941, p. 105, figs. 144-148; MAWATARI, 1952, p. 264.

The present species is easily distinguished from the preceding species by its reddish brown colour of bushy colonies and the zigzag lines occurring on the basal surface of

branches. The bushy tufts reach up to ten centimeters in height and diameter. This form seems to be more abundant in Kabira Bay than *B. neritina*.

5. *Beania cupulariensis* OSBURN, 1914

Beania cupulariensis OSBURN, 1914, p. 190, figs. 6, 7; HARMER, 1926, p. 419, pl. 28, figs. 13, 14; SILÉN, 1941, p. 98, figs. 129–131; MAWATARI, 1952, p. 264.

A small colony of this delicate species was found attached to a shell. The colony was formed with less than ten zooecia, but was doubtlessly identified to the present form by its boat-shaped zooecia with marginal spines and a pair of small distal stalked avicularia.

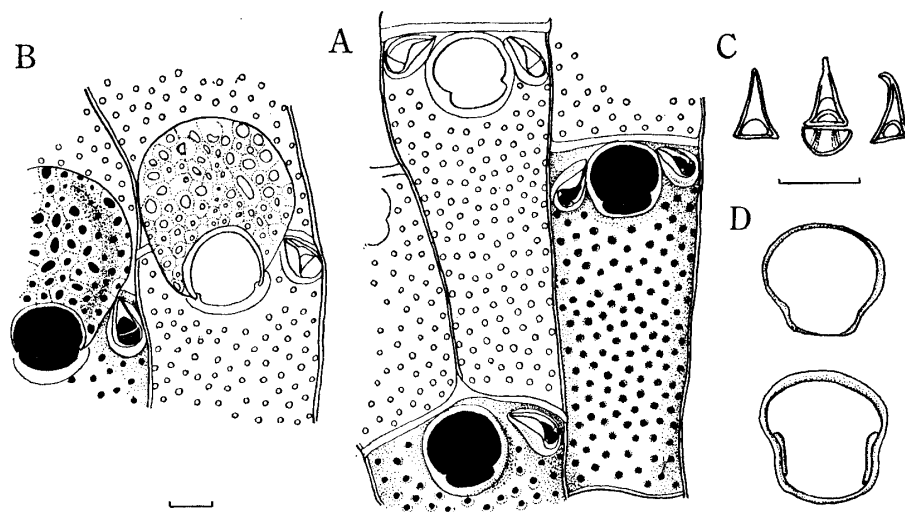


Fig. 2. *Hippopodina feegensis* (BUSK) (Scale 0.1 mm)
A. Ordinary zooecia with paired triangular avicularia. B. Matured zooecia with large, globose, porous ooecia. C. Avicularian mandibles. D. Opercula.

6. *Hippopodina feegensis* (BUSK, 1884)

(Fig. 2, A-D; Pl. 21: 1-3)

Lepralia feegensis BUSK, 1884, p. 144.

Hippopodina feegensis: LEVINSSEN, 1909, p. 353, pl. 24, figs. 3a-f; HASTINGS, 1930, p. 729; OSBURN, 1940, p. 412; 1952, p. 292, pl. 31, figs. 6-8.

A circular incrustation consisted of large zooecia arranged in radiating lines was observed. The slightly raised perforated frontal, a circular aperture with wide proximal sinus, paired distal triangular avicularia pointing obliquely distally and a globose ooecia with distinct pores suggested the present identification.

7. *Celleporaria aperta* (HINCKS, 1880)

(Fig. 3, A-I; Pl. 20: 1-4)

Cellepora aperta HINCKS, 1880, p. 406, pl. 20, figs. 1-2.

Celleporaria aperta HARMER, 1957, p. 729, pl. 42, figs. 6-8.

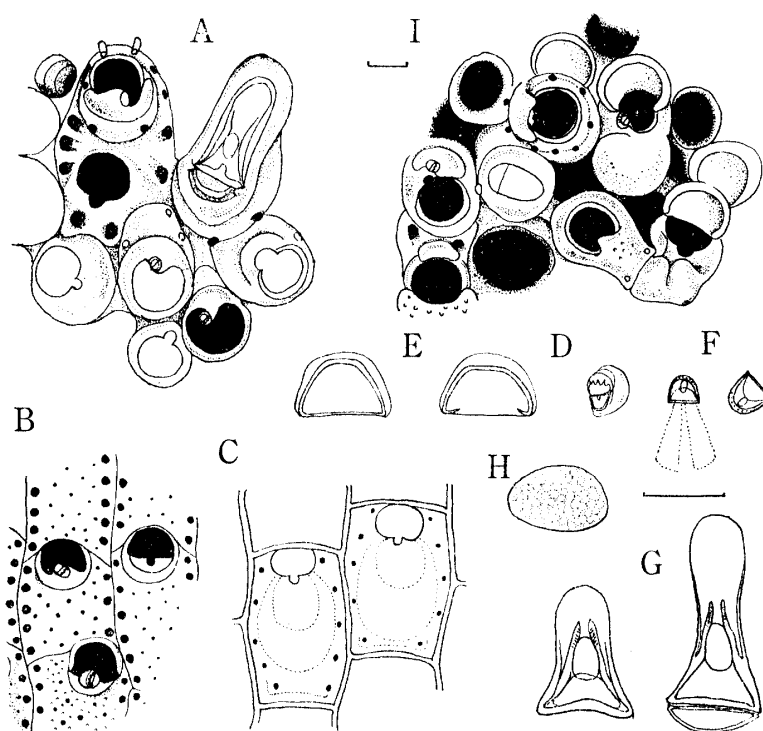


Fig. 3. *Celleporaria aperta* (HINCKS) (Scale 0.1 mm)
 A. Zooecia and a vicarious avicularium. B. Younger zooecia with oral avicularium. C. Primary aperture from inside. D. Oral avicularium with serrated beak. E. Operculum. F. Mandibles of oral avicularia. G. Mandibles of vicarious avicularia. H. Early embryo in the oocium. I. Another part of a zoarium.

Several circular incrusting colonies were obtained. Thickly calcified and projected zooecia give somewhat rough appearance to the zoarium easily distinguished from that of the following species.

The primary zooecial orifice is subcircular with a small median sinus and often concealed by the outgrowth of thickened peristome, which bears a small oral avicularium on one side of the median process. Two or three oral spines are present just distally to the mural rim. The frontal is globose, thickly covered by tubercles and surrounded by distinct areolar pores. A large vicarious avicularium has a raised spatulate rostrum sometimes serrated distally. The operculum is semicircular, mandible of an oral avicularium is semi-elliptical and that of a vicarious avicularium is tongue-shaped with strong marginal and basal sclerites. The oocium is a mere globose projection overhanging the aperture.

8. *Smittina variavicularis* n. sp.

(Figs. 4, A-C, 5, A-I; Pl. 21: 4-9, Pl. 22: 1-9)

Diagnosis. Zoarium incrusting. Zooecia hexagonal, with raised granular frontal surrounded by areolar pores. Primary zooecial aperture is subcircular with a median denticle and lateral cardelles. Secondary aperture variably sinuated, surrounded by proximal and

lateral projections. Frontal avicularium single or paired, with triangular or spatulate rostrum usually directing proximally or laterally. Giant avicularium with elongate, serrated rostrum occurs laterally or centrally. Ooecium globose, perforated and fringed, often immersed.

Description. The colony forms a circular, unilaminar disk of pale greyish colour sometimes exceeding three centimeters in diameter. The zooecia are hexagonal, quadrangular or elliptical, separated by a salient wall and arranged regularly in radiating series. The frontal is usually a granular pleurocyst with marginal areolar pores, but is an olocyst in youngest stage and becomes later a tremocyst with a few large pores. The areolar pores are simple and small in initial stage and gradually change into large, deep, infundibuliform with raised costae extending to the raised median part of the frontal.

The primary aperture is circular or subcircular, provided with a strong median denticle and a pair of small, pointed, lateral cardeles at the proximal border. The primary aperture soon becomes deeply concealed within the produced secondary aperture by the rapid growth of a calcareous peristome. The peristome appears at first as a thin lateral frills or a proximal sinuated projection. Two or three oral spines occur on the distal margin of the peristome but become obscure in the later stage. In the most developed stage of these calcareous projections the secondary aperture takes an eruciform appearance.

The frontal avicularia usually occur on the pleurocystal or tremocystal frontal of adult zooecia, and characteristically variable in shape, size and position. Some zooecia have an elongate linguiform avicularium below the apertural projection laterally or centrally, all directing proximally. Some other zooecia, however, have a triangular, pointed avicularium with raised rostrum directing laterally, and several old zooecia carry a peculiarly elongated giant avicularium with serrate rostrum extending downward.

The rostral serration is characteristic in occurring on smaller avicularia. The mandibles are provided with marginal and basal sclerites.

The ooecia are hyperstomial in nature opening above the primary aperture, but according to the rapid growth of peristomial projections and the progressing secondary calcification of the frontal, they become immersed in the calcareous frontal wall of the succeeding zooecia and usually encircled by the calcareous thickened fringe. The ooecial frontal was perforated by a number of irregular pores.

The ancestrula is elliptical with subcircular aperture surrounded by equally disposed

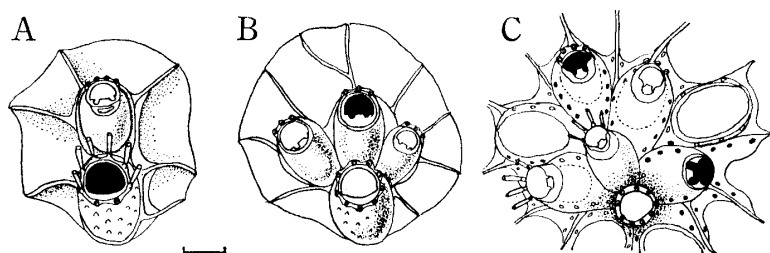


Fig. 4. *Smittina variavicularis* n. sp. (Scale 0.1 mm)

A. Ancestrula with a distal zooecium. B. Ancestrula with three zooecia. C. Concealed ancestrula and periancestrular formation.

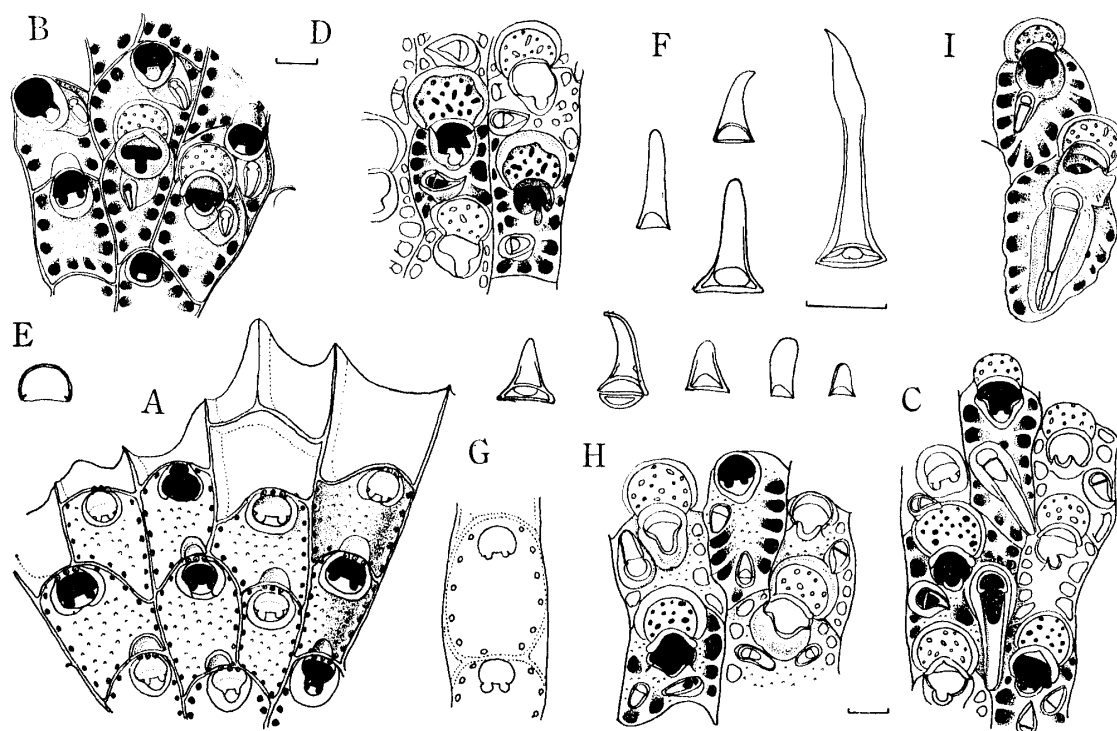


Fig. 5. *Smittina variavicularis* n. sp. (Scale 0.1 mm)

A. Younger zooecia with spines, visible primary aperture, developing peristome and initial stage of ooeonium. B. Zooecia with developed peristome, small linguiform avicularium and various stages of ooeonium formation. C. Zooecia with large, elongate avicularium. D. Zooecia with porous tremocyst and developed ooeonium. E. Operculum. F. Various sorts of avicularian mandibles. H. Triangular and linguiform avicularia pointing to various directions. I. Large, narrow, elongated avicularium with serrate beak.

nine marginal spines. The primary periancestrular zooecia are consisted of one distal and two disto-lateral zooecia of the similar shape. Three distal oral spines and subcircular primary aperture with a median denticle and two lateral cardelles are clearly visible.

Affinities. The present species clearly belongs to the genus *Smittina* in having a frontal granular pleurocyst or tremocyst, areolar pores and costules, a developed median denticles and lateral cardelles, suboral avicularium and porous hyperstomial ooeonium. The elongate giant avicularia have been described only in *S. trispinosa munita* (HINCKS) and *S. trispinosa nitida* (VERRILL), but both of them differs in lacking the serrate rostrum and in having ooeonium perforated by small circular pores. The former has linguiform and triangular mandibles, and the latter has spatulate and triangular mandibles. The present species are most characteristic in the variable shape of mandibles and in the occurrence of an elongated, narrow giant avicularium with a serrate rostrum and a long pointed mandible.

Holotype. Br. 1363 (on *Pinctada margaritifera*)

Type Locality. Kabira Bay, Ishigaki-jima (1973 June 24), Collected by S. MAWATARI.

要 約

八重山群島川平湾においては、琉球真珠会社が内地では養殖不可能な、大型南方系のクロシンジュガいの養殖を行っており、それが生産する黒真珠は本島特産として重要な経済的価値をもっている。しかし、その

垂下養殖の過程において、浮玉、ロープ、網籠のみでなく、貝自身の殻上にも、海綿、ヒドロ虫、イソギンチャク、管棲多毛類、着生性二枚貝、苔虫、ホヤ、サンゴ藻など多様な生物が繁殖して、年間1～2回の面倒な貝掃除を必要としていて、これに対する対策の基礎となる生物学的研究が要望されている。本報告はそのうちの苔虫類に関する研究の結果であり、同定し得た8種のうち、1種は新種 *Smittina variavicularis* として記載された。

この新種の群体はクロチョウガイ生殻の外表面および死殻の内外両面に扁平円盤状をなして着生する。

虫室は幼生の変態によって生じた初室を中心として放射状にならび、しばしば群体直径は3 cmをこえる。

初室は卵形で前半は類円形の開口で占められ、その周縁にはほぼ等間隔に9棘を生ずる。後半をしめる裸壁は微小な粒状物でおおわれるが、やがて周辺虫室の発達によって埋められて、9棘をもつ円形開口のみを示すようになる。環初室虫室群は1個の中央室とこれに隣接する左右2室よりはじまり、やがて後方の2室の発達によって合計5室となる。これらの虫室は前半の開口部に中央歯と側歯を発達せしめる点で、初室と異なり、その開口縁の棘も前方3棘のみを残すことが多い。裸壁は平滑あるいは微粒性でしばしば数個の縁辺孔をもつ。

群体の発達にともなう石灰化の進行につれて、裸壁は肥厚し、顆粒が大きくなるとともに縁辺孔は深くなり、その形も漏斗状となるため、外観はいちじるしく変化して全面が大形の孔で占められた形、あるいは隆起稜におおわれた形となる。一方石灰化は開口部周辺とくにその後方において進行するため、しばしば突起状となって、開口部をおおい、あるいは開口筒を形成する。

これらの裸壁の石灰化と同時に鳥頭体が発達をはじめめるが、その大きさは虫室長の $\frac{1}{3}$ くらいの小形のものから、裸壁全長をおおうほどの大形のものまであり、その位置も開口部直下の中央、側位をしめるもの、裸壁中央部あるいは後部にあるものなどがある。また、その形も、卵形、楕形、長形などがあり、顎も舌状、三角状、長嘴状など変化が多く、本種のいちじるしい特徴となる。また、その方向も後方、斜後方、側方、前方、斜前方などあらゆる方向に向く。とくに長嘴状の顎をもった巨大な鳥頭体はその嘴部に明らかな鋸歯を示す。

卵室は典型的の口上卵室型に属するが、これも半球形で微小孔を穿つものから、肥厚して虫食い状孔を穿ち、周辺に石灰質の厚い帯をめぐるものまで変化が多い。

本種は、その多種多様な鳥頭体の変化的発達において他に類を見ない特徴を示すので、新種と認定する。

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Explanation of Plates 20-22

Plate 20

Celleporaria aperta (HINCKS)

1. A colony incrusting a shell of black lip oyster.
2. Crowded zooecia and a vicarious avicularium with elevated rostrum.
3. The same, seen by transmitted light to show primary apertures and a spatulate mandible.
4. Oral avicularia on the median process, carrying a semi-elliptical mandible.

Thalamoporella rozieri (AUDOUIN)

5. Two growing and four completed ooecia and four vicarious avicularia.
6. A colony spreading over a shell.
- 7, 8. Ordinary zooecia encircled by beaded rim, showing subcircular aperture with rounded sinus, granular tube, symmetrical opesiules and porous cryptocyst.
9. Two matured zooecia supporting globose ooecium.
10. Two developing ooecia showing the bilobate structure and a spatulate vicarious avicularium smaller than the symmetrical sister zooecium at the bifurcation of zooecial rows.

Plate 21

Hippopodina feegensis (BUSK)

1. An ordinary zooecium with subcircular aperture and paired triangular oral avicularia and three globose, porous ooecia.
2. Porous structure of zooecium and ooecium. A triangular avicularium is seen at a side of an aperture.
3. An incrusting colony with radially arranged zooecia.

Smittina variavicularis n. sp.

4. A young and a grown up colonies
5. Young zooecia showing the primary aperture with a median denticle and a pair of lateral cardelles.
6. A colony showing oral spines, areolar pores, produced peristome and frontal avicularia.
7. Zooecia with ordinary elongate avicularia.
8. Porous ooecia and large, elongate, linguiform, lateral avicularia.
9. Two large, elongate, narrow, median avicularia with serrated beak.

Plate 22

Smittina variavicularis n. sp.

1. Young zooecia with visible primary aperture.
2. Circular primary aperture with a median denticle and a pair of lateral cardelles.
3. Young zooecium with two distal oral spines.
4. Aged zooecia with porous ooecia and raised triangular avicularia.
5. A large, elongate linguiform, lateral avicularium.
6. A large, elongate, narrow median avicularium with serrated beak and flagelliform mandible.
7. Thickened peristomes, proous ooecia and a small linguiform avicularium.
8. Porous tremocyst of ovicelled zooecia.
9. Small and medium linguiform avicularia.

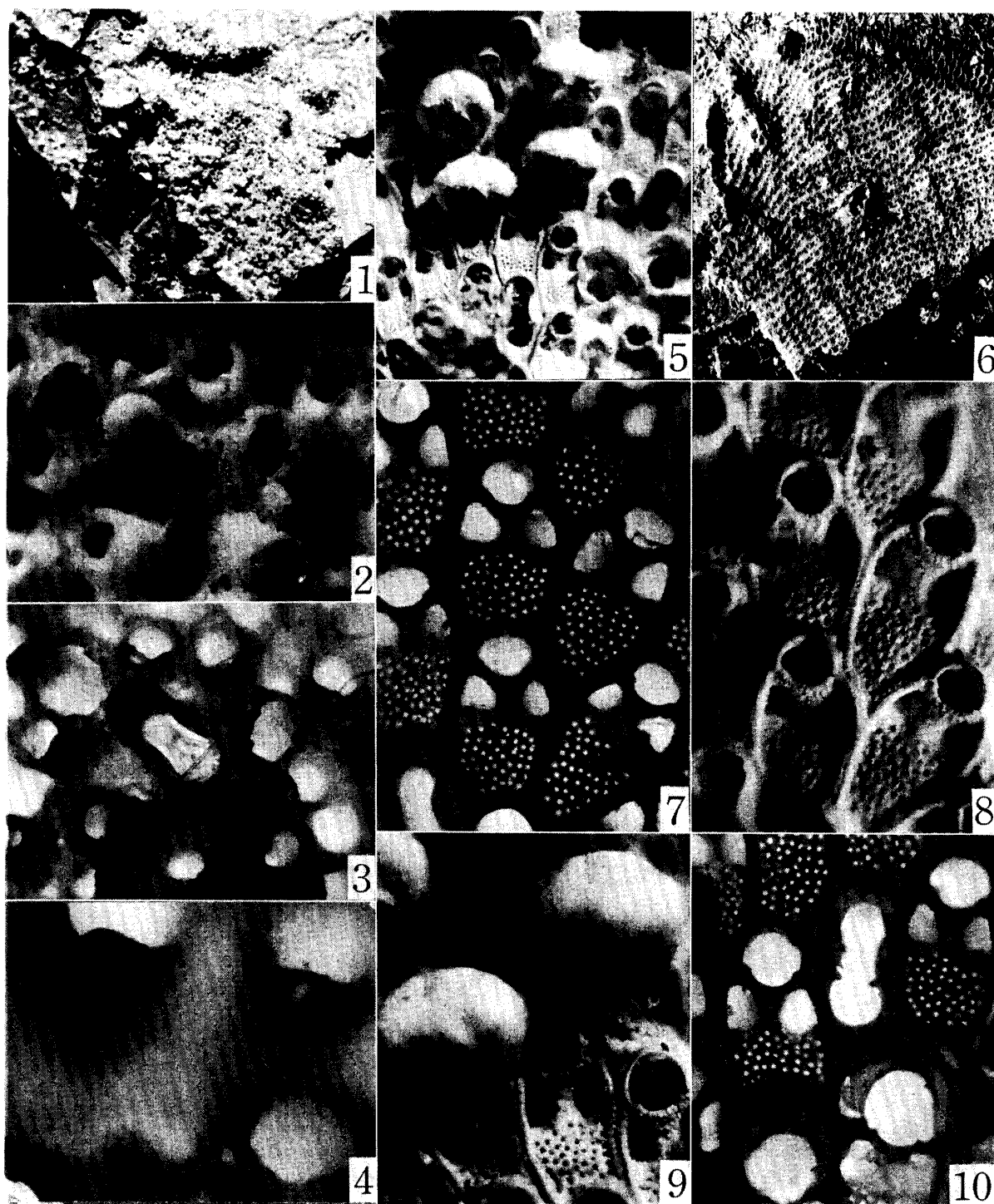


Plate 21

MAWATARI: Fouling Bryozoans in Black Lip Oyster

